List of Figures

Chapter Forty-five

CROSS SECTION ELEMENTS

Chapter Fifty-three provides numerical criteria for various cross section elements on new construction and reconstruction projects. Chapters Fifty-four through Fifty-six provide criteria for cross section elements on existing highways. Chapter Forty-five will provide additional guidance which should be considered in the design of these cross section elements. The designer should also review the typical cross sections presented in Section 45.8.0.

45-1.0 ROADWAY SECTION

<u>45-1.01 Travel Lanes</u>

45-1.01(01) Width

Travel lane widths can vary between 2.7 m and 3.6 m, depending upon the functional classification, traffic volumes, design speed, rural/urban location and project scope of work. The tables in Chapters Fifty-three through Fifty-six provide specific criteria for travel lane widths for these various conditions.

45-1.01(02) Cross Slopes

Surface cross slopes are required for the proper drainage of through travel lanes on tangent sections. This reduces the hazard of wet pavements by quickly removing water from the surface, and it reduces the likelihood of ponding. On State highways, the following will apply for tangent roadway sections:

1. <u>Two-Lane Highways</u>. The travelway lane pavement should be crowned at the centerline with a cross slope of 2% sloping away from the center.

2. Divided Facilities. For divided facilities with two lanes in each direction, each roadway is crowned at the centerline with a cross slope of 2% sloping away from the center. For divided facilities with three or more lanes in each direction, the following will apply:

   a. Three-Lane Sections (New Construction/Reconstruction). The pavement is typically crowned along the lane edge between the middle lane and the lane adjacent to the median, with the right two lanes sloping to the outside. All travel lane cross slopes should be 2%.

   b. Three-Lane Sections (Adding Lanes to Existing Facilities). When adding new lanes in the median or on the outside, the existing roadway crown is typically maintained. The added travel lane cross slope direction and rate will generally be the same as the adjacent travel lane or where three lanes are sloped in the same direction, the third lane should desirably be sloped at 3%.

   c. Four-Lane Sections. The travelway pavement should be crowned at the centerline (i.e., two lanes on each side) with a cross slope of 2% sloping away from the center. Where three or more lanes are sloped in the same direction, the third (and fourth) lane should desirably be sloped at 3%.

   d. Existing. For roadways with existing 2-lane, 75-mm sloped sections, increase the overlay depth by 75 mm on the inside edge to achieve a uniform 2% cross slope downward across both travelway lanes. For three lanes sloped in one direction, use a 3% cross slope for the outside lane. If the additional lane is to be added in the median, it should be sloped at 2% toward the median.

3. Bridges. For new or reconstructed bridges, the cross slope will typically be 2% sloping away from the crown and will apply to the entire width from the crown to the face of the rail or curb. The crown across the bridge will typically be in the same location as the approaching roadway. Note that existing bridges to remain in place may retain an existing cross slope of 1.5%.

For non-State highways, the travel lane cross slopes will vary depending upon the pavement surface and local practices. In general, for paved surfaces, the cross slope should be the same as for State highways (i.e., 2%). For non-State facilities with aggregate surfaces, the cross slope is typically 6%.

45-1.02 Shoulders/Curb Offsets

45-1.02(01) Definitions

The following definitions apply to the term "shoulder":

1. Shoulder. The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use and for lateral support of subbase, base and surface course.

2. Usable Shoulder Width. The width of the shoulder that can be used by a driver for emergency parking or stopping. Figure 45-1A, Usable Shoulder Width, illustrates the definition.

3. Effective Usable Shoulder Width. This width is equal to the usable shoulder width minus 0.3 m. However, the effective usable shoulder width cannot be less than the required paved shoulder width.

4. Curb Offset. This term will be used to define the distance between the edge of the travel lane and the face of curb.

45-1.02(02) Functions

Shoulders serve many functions. The wider the shoulder, the greater the benefits, including the following:

1. providing structural lateral support for the travelway;
2. increasing highway capacity;
3. encouraging uniform travel speeds;
4. providing space for emergency and discretionary stops;
5. improving roadside safety by providing more recovery area for run-off-the-road vehicles;
6. providing a sense of openness;
7. improving sight distance around horizontal curves;

8. enhancing highway aesthetics;

9. facilitating maintenance operations (e.g., snow storage);

10. providing additional lateral clearance to roadside appurtenances (e.g., guardrail, traffic signals);

11. facilitating pavement drainage;

12. providing space for pedestrian and bicycle use; and

13. providing space for bus stops.

45-1.02(03) Widths

Shoulder widths will vary according to functional classification, traffic volumes, urban/rural location, curbed/uncurbed facilities and the project scope of work. The tables in Chapters Fifty-three through Fifty-six present the paved and usable shoulder width criteria for these various conditions. See Section 49-5.0 for shoulder widths where guardrail is required.

45-1.02(04) Surface Types

For new or reconstructed projects on State highways, all shoulders will be either paved with asphalt or concrete. Desirably, on 3R and partial 3R projects on State highways, the shoulder should be paved. However, sealed aggregate shoulders may be appropriate on some State highways. For non-State highways, desirably, the shoulder should be paved. However, a sealed aggregate or earth surface is acceptable.

45-1.02(05) Cross Slopes

The cross slope of the shoulder varies according to the shoulder type and width. It should be the same across the full width of the usable shoulder. One exception is noted in Section 55-4.03(02) Item 4. The tables in Chapters Fifty-three through Fifty-six provide the cross slopes used for each classification. For narrow shoulders (e.g., shoulder widths that are less than 1.2 m), the shoulder cross slope will typically be the same as the adjacent travel lane. The following summarizes INDOT and local public agency practices.

1. Paved. Typical cross slopes for paved shoulders are 4%.

2. Curb Offsets. Curb offsets are paved and will have the same cross slope as the adjacent travel lane, which is typically 2%.

3. Aggregate. Typical cross slopes for aggregate shoulders are 4 to 6%.

4. Earth. Earth shoulders typically have a cross slope of 6 to 8%.

45-1.02(06) Shoulder Corrugations

Shoulder corrugations should be considered for shoulders only on a roadway designed as a rural facility.

The minimum paved width for an outside shoulder to be corrugated is 1.8 m. If guardrail, concrete barrier railing, or another type of roadside barrier is adjacent to an outside shoulder, such minimum paved width is 2.1 m. The minimum paved width for a median shoulder to be corrugated is 1.2 m.

Shoulder corrugations should be milled, without regard to the shoulder pavement material.

45-1.03 Auxiliary Lanes

Auxiliary lanes include left- and right-turn lanes, acceleration and deceleration lanes, and climbing lanes. Desirably, auxiliary lanes should be the same width as the adjacent travel lanes, but not less than 3.0 m. The tables in Chapters Fifty-three through Fifty-five provide the specific width criteria for auxiliary lanes. The tables also provide the criteria for shoulder width adjacent to auxiliary lanes.

The cross slope for the auxiliary lane should generally be 1% greater than the adjacent through lane.

Chapter Forty-six presents additional information for two-way left-turn lanes.

45-1.04 Parking Lanes (On-Street)

For most urban projects, the designer must evaluate the demand for parking. Desirably, these parking needs will be accommodated by providing off-street parking facilities. Chapter Fifty-one provides information on the design and layout of off-street parking facilities. When providing on-street parking along urban streets, the designer should evaluate the following:

1. Warrants. Adjacent land use may create the need to provide on-street parking along an urban street. Parking lanes provide convenient access for motorists to businesses and residences. However, on-street parking reduces capacity, impedes traffic flow and may produce undesirable traffic operations or may increase the accident potential. Therefore, it is INDOT's policy not to introduce new parking lanes along State highways. In addition, the designer should consider removing parking lanes on State reconstruction (4R) projects, wherever practical. Removal of existing or revising existing on-street parking configurations will require concurrence from local officials and "official action" by INDOT.

2. Configuration. The two basic types of on-street parking are parallel and angle parking. These are illustrated in Figure 45-1B, Curb Parking Configurations. Parallel parking is the preferred arrangement when street space is limited and traffic capacity is a major factor. Angle parking provides more spaces per linear meter than parallel parking, but a greater cross street width is necessary for this design. The total entrance and exit time for parallel parking exceeds that required for angle parking. Parallel parking also requires a vehicle to stop in the travel lane and await an opportunity to back into the parking space. However, the designer should also consider that angle parking requires the vehicle to back into the lane of travel when sight distance may be restricted by adjacent parked vehicles and when this maneuver may surprise an approaching motorist.

   When selecting the parking configuration, the designer should evaluate the operational consequences of the selection. In particular, the designer should consider the backing maneuver required by angle parking. As indicated in Figure 45-1B, the parked car will require a certain distance B to back out of its stall. Whether or not this is a reasonably safe maneuver will depend upon the number of lanes in each direction, lane widths, operating speeds, traffic volumes during peak hours, parking demand and turnover rate of parked vehicles.

   On new construction projects, only parallel parking should be provided. Any existing facility with angle parking should desirably be converted to parallel parking. Any changes to existing on-street parking will require concurrence from local officials and "official action" by INDOT.

3. Stall Dimensions. Figure 45-1B provides the width and length criteria for parking stalls for various configurations. The figure also indicates the number of stalls which can be provided for each parking configuration for a given curb length.

   The tables in Chapters Fifty-three and Fifty-five provide parking lane widths for parallel parking. For angle parking, desirably, the parking lane width will be a combination of dimensions A and B as shown in Figure 45-1B exclusive of the through travel lane. However, in restricted areas a portion of the B dimension may be required for the through travel lane, thereby reducing the actual parking lane widths. See Figure 45-1C, Desirable Street Widths With On-Street Parking.

   Section 51-1.03 provides information on the parking stall dimensions for handicapped parking spaces.

4. Cross Slope. The cross slope of the parking lane will typically be 1% steeper than that of the adjacent travel lane (i.e., parking lane cross slopes are typically 3%).

5. Handicapped. Section 51-1.03 presents the handicapped accessibility requirements for on-street parking.

6. Location. When locating parking spaces, the designer should consider the following:

   a. Parking is prohibited within 6.1 m of any crosswalk.

   b. Parking should be prohibited within 3-5 m of the beginning of the curb radius at mid-block driveway entrances.

   c. Parking is prohibited within 15.2 m of the nearest rail of a railroad/highway crossing.

   d. Parking is prohibited within 4.6 m of a fire hydrant.

   e. Parking is prohibited within 9.1 m on the approach leg to any intersection with a flashing beacon, stop sign, or traffic control signal. For no-controlled or yield-controlled intersection, parking is not allowed within the intersection itself.

   f. Parking is prohibited within 6.1 m on the near side of a fire station driveway entrance and 230 m from the entrance for the opposite side of the street.

g. Parking is prohibited on bridges or within a highway tunnel.

h. Parking is prohibited along the same side or opposite a street excavation or obstruction if it would obstruct traffic.

i. Parking should be prohibited from areas designated by local traffic and enforcement regulations (e.g., near school zones, loading zones, bus stops). See local ordinances for additional information on parking restrictions.

<u>45-1.05 Curbs</u>

Curbs are often used on urban facilities to retain the cut slope, control drainage, delineate the pavement edge, reduce right-of-way requirements, channelize vehicular movements, and improve aesthetics. In urban areas, curbs have a major benefit in containing the drainage within the pavement area and in channelizing traffic into and out of adjacent properties.

45-1.05(01) Warrants (Curbed Section)

Selecting a curbed section or uncurbed section depends upon many variables, including vehicular speeds, urban/rural location, drainage and construction costs. The following discusses those factors which will determine whether or not a curbed section is warranted:

1. <u>Urban Location</u>. Because of restricted right-of-way and other constraints, curbed sections are typically used in urban areas.

2. <u>Suburban Location</u>. Where design speeds are greater than 70 km/h, uncurbed sections are typically used. The exceptions listed under Item 3 below for rural locations also apply to high-speed suburban facilities. Where design speeds are less than 80 km/h, the use of a curbed or uncurbed section will be made on a project-by-project basis considering right-of-way constraints, drainage, pedestrian activity, channelization needs, driveway access control, etc.

3. <u>Rural Location</u>. The use of curbs on rural highways is usually limited to conditions such as the following:

a. where there is sufficient development along the highway and there is a need to channelize traffic into and out of properties;

b. where it is absolutely necessary to control drainage;

c. where restricted right-of-way provides no room for roadside ditches or to lessen property impacts;

d. to prevent soil erosion; and/or

e. at other sites deemed absolutely necessary.

45-1.05(02) Types

There are generally two types of curbs, sloping and vertical. INDOT sloping curbs typically have a height of 100 mm or less with a face batter no steeper than approximately one horizontal to one vertical. Vertical curbs may range in height between 150 mm and 205 mm with a face batter steeper than one horizontal to six vertical.

When curbs are used with asphalt pavements, either a standard concrete curb or a combined concrete curb and gutter may be used. However, the combined concrete curb and gutter is preferred due to its improved drainage capacity, stability and pavement delineation. For concrete pavements an integral concrete curb is generally used. Figure 45-1D, Curbing Types, illustrates the typical curbs used by the Department. The INDOT *Standard Drawings* provide additional design details for these and other curb types.

45-1.05(03) Curb Type Selection

1. Materials. Concrete curbs are typically used. However, for projects on existing facilities, asphalt curbing, not to exceed 100 mm in height, may be used under guardrail to control erosion. Asphalt curbing may also be used for temporary islands, temporary medians within construction zones, etc. Where snow plowing operations are conducted, asphalt curbing may be subject to severe damage or total removal. Therefore, it should not be used where damage from snow plows can be expected.

2. Speed. Vertical curbs are generally only used on low-speed, urban facilities where the design speed is less than 80 km/h. Preferably, curbs should not be used along rural and high-speed urban highways (i.e., those with design speeds of 80 km/h or greater). If curbs are deemed necessary, only sloping curbs located at the edge of the shoulder should be used on these high-speed facilities.

3. Vehicular Encroachment. Although at lower speeds vertical curbs may deflect a vehicle, they should not be used in lieu of guardrail as protection from hazardous objects. Where vehicular encroachment is permissible, sloping curbs should be used.

4. Sidewalks. Where sidewalks are present or to be constructed in urban areas, curbs may be used. Consideration should be given to the types of curbs existing or proposed in similar conditions within the adjacent geographical area.

5. Islands. Where divisional or directional islands are used, a raised corrugated island should be used. Section 46-9.0 and the INDOT *Standard Drawings* provide additional information on the design and placement of raised corrugated islands.

6. Local Practices. On State highways, the designer should strive to meet the prevailing local practice where it does not conflict with Department criteria. Where local practices differ, INDOT criteria should prevail. On non-State facilities, local practices will normally govern.

45-1.05(04) Design Considerations

The use of a curbed section requires the consideration and implementation of many design elements. The following discusses these design considerations:

1. Drainage. Department practices limit the allowable amount of water ponding on the roadway. A closed drainage system is generally almost always used with curbed sections. The hydraulic analysis will, among other factors, depend on several curb characteristics. These include type of material (concrete or asphalt), cross slopes leading up to the curb, and shape of the curb face. In addition, it may be desirable or necessary to prevent the gutter flow from overtopping the curb. This will affect the selected curb height. See Chapter Thirty-six for specific criteria and procedures for drainage analysis.

   The minimum profile grade in a curbed section is $\pm 0.3\%$. Additional consideration should be given to minimum grades in curbed superelevation transition areas to avoid drainage problems. The following two criteria will alleviate such problems.

a. A minimum profile grade of $\pm$0.5% should be maintained through a superelevation transition section.

b. A minimum edge of pavement grade of $\pm$0.5% should be maintained through a superelevation transition section. The equations to be considered for this criterion are as follows:

$$G \leq -\Delta^* - 0.5 \quad \text{[Equation 45-1.1]}$$

$$G \geq -\Delta^* + 0.5 \quad \text{[Equation 45-1.2]}$$

$$G \leq \Delta^* - 0.5 \quad \text{[Equation 45-1.3]}$$

$$G \geq \Delta^* + 0.5 \quad \text{[Equation 45-1.4]}$$

$$\Delta^* = \frac{wne_d}{L_r} \quad \text{[Equation 45-1.5]}$$

where,

G = profile grade, %;
Δ^* = effective maximum relative gradient, %;
w = width of one traffic lane, m (typically 3.6)
n = number of lanes rotated;
e_d = design superelevation rate, %;
L_r = length of superelevation runoff, m.

* * * * * * * *

EXAMPLE 45-1.01

To illustrate the combined use of the two criteria, consider the following:

Δ^*= 0.65% in the transition section

Criterion 1.a. described above excludes grades between –0.5% and +0.5%.
Criterion 1.b. excludes grades between -1.15% (via Equation 03-19.1, where G $\leq$ -0.65 - 0.5, or -1.15), and -0.15% (via Equation 03-19.2, where G $\geq$ -0.65 + 0.5, or -0.15).
Also, Criterion 1.b. excludes grades between +0.15% (via Equation 03-19.3, where G $\leq$ +0.65 - 0.5, or +0.15), and +1.15% (via Equation 03-19.4, where G $\geq$ +0.65 + 0.5, or +1.15).

Therefore, the profile grade within the transition must be outside the range of –1.15% to +1.15% in order to satisfy both criteria and provide adequate pavement surface drainage.

See the AASHTO *A Policy on Geometric Design of Highways and Streets* for more information.

2. Cross Slopes. Where an integral curb and gutter section is used, the cross slope of the gutter is the same as the adjacent pavement surface. Where a separate curb and gutter section is used, the gutter pan cross slope is as shown in Figure 45-1D, Curbing Types.

3. Roadside Safety. The placement of barriers behind curbs must meet placement and height criteria. Chapter Forty-nine discusses roadside safety criteria relative to curbs.

4. Future Resurfacing. The designer should consider the likelihood and depth of a future resurfacing course when determining the initial curb height. For example, the curb height may be determined by the sum of the water overtopping depth (based on a drainage analysis) and the future resurfacing depth. Because milling of the pavement is becoming more prevalent, additional curb height may not be a consideration.

5. Parking Considerations. Desirably, curb heights next to on-street parking should be 150 mm or less. This will allow clearance for the opening of car doors. Curb heights on streets and parking lots with diagonal or perpendicular parking should also be limited to 150 mm maximum height to prevent underside vehicle damage.

6. Freeze/Thaw Considerations. The combined curb and gutter design removes the pavement joint away from the face of curb. After several freeze/thaw cycles, standard curb types may become uneven and present an unsightly appearance; therefore, integral/combined curbs are preferable.

7. Handicapped Accessibility. Curbs should be designed with curb ramps at all pedestrian crosswalks to provide adequate access for the safe and convenient movement of physically handicapped individuals. Section 51-1.08 and the *INDOT Standard Drawings* provide details on the design and location of curb ramps.

45-1.06 Sidewalks

Sidewalks are considered integral parts of the urban environment. In these areas, travelers frequently choose to make all or part of their trip on foot, and pedestrians desire to use a paved surface for the trip. In rural areas, sidewalks are less common, but they may have sufficient value in developed rural areas, especially in the vicinity of schools, to warrant their construction.

45-1.06(01) Guidelines for Sidewalk Warrants

The following guidance applies to providing sidewalks in the project design.

1. Sidewalks Currently Exist. Where sidewalks currently exist and will be disturbed by construction, the sidewalk will be reconstructed in kind. If a bridge with an existing pedestrian sidewalk is reconstructed, the sidewalk will typically be retained.

   If a sidewalk exists only on one side of the State highway or bridge, the project will often include the construction of a new sidewalk on the other side. However, the funding and maintenance arrangements will be according to the criteria in Item 5 below.

2. Sidewalks Currently Do Not Exist (Roadway). The warrants for sidewalks depend upon if the project is inside or outside the city corporate limits. The following provides guidance for each of these situations:

   a. Projects Within City Corporate Limits. At the preliminary field check stage, the designer should arrange a meeting between the appropriate District personnel and city officials to make a collective determination on the need for sidewalks. If the city indicates that the sidewalks are needed and requests that they be included as part of the project, then the project will include the sidewalks. If Federal funds are used, the Department may elect to help pay for the construction of new sidewalks. However, if no Federal funds are used, this will require a reimbursement agreement between the State and city in accordance with Item 5. If the city indicates that the sidewalks are needed but does not want them included as part of the project, then the designer should develop the plans so that a graded grassed area is provided for a future sidewalk. The city will be responsible for installing the sidewalk in the future.

   b. Projects Outside City Corporate Limits (Towns/Rural Areas). The Department may install sidewalks if it deems them necessary. The need for sidewalks on State or non-State facilities will be determined on a case-by-case basis. No numerical warrants are available. In general, the designer should consider providing sidewalks along any roadway where pedestrians normally move or would be expected to move if they had a sidewalk available (i.e., a latent demand exists such as evidence by pathways along highways).

Once the decision is made to provide a sidewalk along a roadway, the need for a sidewalk on both sides of the roadway will be determined on a case-by-case basis.

3. Sidewalks Currently Do Not Exist (Bridges). If a bridge is within the limits of a reconstruction (4R) or 3R project and if its bridge deck will be rehabilitated as part of the project, sidewalks will be provided on the bridge if provided on the approach roadway. If the bridge deck will not be rehabilitated as part of the reconstruction or 3R project, it will rarely be warranted to perform work solely to provide sidewalks on the bridge unless sidewalks exist on the approaching roadway.

   Bridge deck rehabilitation may be the only work on the 3R project. Sidewalks may be on the approach roadway or the approach roadway may be a candidate for future sidewalks according to the discussion in Item 2. If so, sidewalks should be included as part of the bridge deck rehabilitation project.

   Once the decision is made to provide a sidewalk on a bridge, one will normally be constructed on each side, unless there is a justifiable reason to place a sidewalk on only one side.

4. Sidewalks Currently Do Not Exist (Underpasses). An underpass may be within the limits of a project. If the approach roadway will have sidewalks, these will be provided through the underpass, unless this would involve unreasonable costs to relocate the bridge substructure. A bridge reconstruction project may involve major work on or the replacement of the bridge substructure. If the bridge passes over a roadway, the designer should consider allowing space for the future addition of sidewalks through the underpass.

   Once the decision is made to provide a sidewalk through an underpass, one will normally be constructed along each side, unless there is a justifiable reason to place a sidewalk on only one side.

5. Funding and Maintenance Considerations. Sidewalk funding and maintenance considerations are dependent upon project location. The following will apply.

   a. Towns/Rural Areas. New sidewalks constructed in towns and in rural areas outside of city limits may be funded with State and Federal funds. This includes all the costs for grading, construction and right-of-way.

   b. City Limits. For sidewalks constructed within the corporate city limits, the city will be responsible for the costs of constructing the sidewalk unless Federal funds are used; then the State may participate. If totally funded by the city, a reimbursement agreement will be required between the Department and the city prior to the project letting. The State will be responsible for the cost of right-of-way and any grading required specifically for the sidewalk.

c. Bridges. Regardless of location, the total cost for sidewalks on bridges may be funded with State and Federal funds.

45-1.06(02) Sidewalk Design Criteria

In determining the sidewalk design, the designer should consider the following:

1. Widths. A typical sidewalk is 1.5-m wide with a 1.5-m buffer area between the roadway and sidewalk. If there is no buffer area provided, the sidewalk should be 1.8-m wide to accommodate any appurtenances which may be included in the sidewalk (see Item #4).

   High pedestrian volumes may warrant greater widths in, for example, commercial areas and school zones. In these cases, the designer may conduct a detailed capacity analysis to determine the sidewalk width. The *Highway Capacity Manual* should be used for this analysis.

2. Handicapped Accessibility. In general, all sidewalks should meet the handicapped accessibility criteria presented in Section 51-1.05(01). Where this is not practical, the criteria in Section 51-1.05(02) may be used.

3. Urban Areas. In central business districts, the entire area between the curb and building is often fully used as a paved sidewalk.

4. Appurtenances. The designer should also consider the impacts of roadside appurtenances within the sidewalk (e.g., fire hydrants, parking meters, utility poles). These elements will reduce the effective usable width because they interfere with pedestrian activity. Preferably, these appurtenances should be placed behind the sidewalk. If they are placed within the sidewalk, the sidewalk should be widened accordingly.

5. Cross Slope. The typical cross slope on the sidewalk is 2%. If the sidewalk is on an accessible route, then the maximum cross slope will be 2%. See Section 51-1.05

6. Buffer Areas. If the available right-of-way is sufficient, buffer areas between the curb and sidewalk are desirable. These areas provide space for snow storage and allow a greater separation between vehicle and pedestrian. The buffer area should be at least 1.5-m wide to be effective and should desirably be wider. Buffer areas may also be used for the placement of roadside appurtenances, if necessary. However, this is undesirable because the proximity to the traveled way increases the likelihood of vehicle/fixed-object accidents, and their presence in buffer areas detracts from the appearance of the highway environment.

7. Pedestrian Railings (on Bridges). Chapter Fifty-nine provides criteria for when a pedestrian rail will be required on a bridge. Chapter Forty-nine provides information for the treatment of blunt ends of pedestrian rails.

45-2.0 MEDIANS

A median is desirable on many multi-lane highways. The principal functions of a median are as follows:

1. to provide separation from opposing traffic,
2. to prevent undesirable turning movements,
3. to provide an area for deceleration and storage of left-turning vehicles,
4. to provide an area for storage of vehicles crossing the mainline at intersections,
5. to facilitate drainage collection,
6. to provide an area for snow storage,
7. to provide an open green space,
8. to provide a recovery area for out-of-control vehicles,
9. to provide a refuge area in case of emergencies,
10. to minimize headlight glare,
11. to provide an area for pedestrian refuge, and
12. to provide space for future lanes.

45-2.01 Median Widths

In general, the median should be as wide as can be used advantageously. The median width is measured from the edge of the two inside travel lanes and includes the left shoulders or curb offsets. The design width will depend on the functional class of the highway, type of median, availability of right-of-way, construction costs, maintenance considerations, the acceptable median slopes, the anticipated ultimate development of the facility, operations at crossing intersections and field conditions. In addition, the designer should consider the following to determine an appropriate median width:

1. Left Turns. The need for left-turn bays should be considered when selecting a median width.

2. Crossing Vehicles. A median should be approximately 8.0-m wide to safely allow a crossing passenger vehicle to stop between the two roadways. In areas where trucks are commonly present (e.g., truck stops), the median width should be increased to allow trucks to stop between roadways. The appropriate design vehicle for determining median width should be chosen based on the actual or anticipated vehicle mix of crossroad- and other traffic crossing the median.

3. Signalization. At signalized intersections, wide medians can lead to inefficient traffic operations and may increase crossing times.

4. Median Barriers. With narrow medians, a median barrier may be warranted. Therefore, the median will desirably be wide enough to eliminate the need for a barrier. See Section 49-4.05.

5. Operations. Several vehicular maneuvers at intersections are partially dependent on the median width. These include U-turns and turning maneuvers at median openings. The designer should evaluate the likely maneuvers at intersections and provide a median width that will accommodate the selected design vehicle. See Section 46-8.01 and Item 2 above.

6. Separation. From the driver's perspective, median widths of 12 m physically and psychologically separate him/her from the opposing traffic.

7. Uniformity. In general, a uniform median width is desirable. However, variable-width medians may be advantageous where right-of-way is restricted, at-grade intersections are widely spaced (800 m or more), or an independent alignment is practical.

8. Other Elements. The widths of the other roadway cross section elements should not normally be reduced to provide additional median width.

Section 45-8.0 include typical roadway cross section figures which also provide design details for medians. Chapter Fifty-three presents specific numerical criteria for median widths on new construction/reconstruction projects. On existing highways, retainage of the existing median width will be determined on a case-by-case basis.

45-2.02 Median Types

Figure 45-2A, Median Width Definitions, illustrates the basic median types: flush, flush with concrete median barriers, raised and depressed. The following sections provide additional information on these median types.

45-2.02(01) Flush Medians

Flush medians are often used on urban highways and streets. A flush median should be slightly crowned to avoid ponding water in the median area. However, flush medians with concrete median barriers should be depressed to collect water within a closed drainage system.

The typical width for a flush median on an urban street ranges from 1.2 m to 4.8 m. If the median width is 4.8 m or less, the designer could consider using a continuous raised corrugated median or a slightly mounded median curb with 25 to 50 mm edge height. A corrugated type of median should generally be used where there is little or no anticipation that motorists will drive onto the median to make a left turn. The *INDOT Standard Drawings* provide additional details on the design of corrugated and mounded medians. To accommodate a left-turn lane, a flush median should be 4.2-m wide. This will allow a 3.6-m turn lane and a minimum 0.6-m separation between left-turning vehicles and the opposing traffic.

Two-way left-turn lanes (TWLTL) are also considered flush medians. Desirably, the roadway cross section with a flush median will allow ultimate development for a TWLTL. The tables in Chapters Fifty-three, Fifty-five and Fifty-six provide the criteria for TWLTL widths. Section 46-5.02 provides information on design details for TWLTL at intersections.

A flush median with a concrete median barrier may be used on urban freeways where the right-of-way does not allow for the use of a depressed median. For new construction and complete reconstruction projects, the minimum width of a flush median for an urban freeway is 8.0 m. This allows the use of two 3.6-m left shoulders and for the width of the concrete median barrier. On partial reconstruction projects, the minimum width may be the existing median width.

45-2.02(02) Raised Medians

Raised medians are often used on urban highways and streets to control access and left turns and to improve the capacity of the facility. Figure 45-2A, Median Width Definitions, illustrates a typical raised median.

When compared to flush medians, raised medians offer several advantages as follows:

1. Mid-block left turns are controlled.

2. Left-turn channelization can be more effectively delineated if the median is wide enough.

3 A distinct location is available for traffic signs, signals, pedestrian refuge and snow storage.

4. The median edges are much more discernible during and after a snowfall.

5. Drainage collection may be improved.

6. Limited physical separation is available.

The disadvantages of raised medians when compared to flush medians are as follows:

1. They are more expensive to construct and more difficult to maintain.

2. They may need greater widths to serve the same function (e.g., left-turn lanes at intersections) because of the raised island and offset between curb and travel lane.

3. Curbs may result in adverse vehicular behavior upon impact.

4. Prohibiting mid-block left turns may overload street intersections and may increase the number of U-turns.

5. They may complicate the drainage design.

6. Access for emergency vehicles is restricted.

If a raised median will be used, the designer should consider the following in the design of the median.

1. Design Speed. Because of the possible adverse effect curbs can have on a vehicular behavior if impacted, raised medians should only be used where the design speed is less than 80 km/h.

2. Curb Type. Either barrier or mountable curbs with edge height of 25 to 50 mm or more may be used.

3. Appurtenances. If practical, the placement of appurtenances within the median is strongly discouraged (e.g., traffic signal poles, light standards).

4. Desirable Width. If practical, the width of a raised median should be sufficient to allow for the development of a channelized left-turn lane. This yields a 5.4-m median width assuming:

   a. a 3.6-m turn lane,
   b. a 0.6-m curb offset between the opposing through lane and raised island, and
   c. a minimum 1.2-m raised island.

5. Minimum Width. The recommended minimum width of a raised median should be 2.4 m. This assumes a minimum 1.2-m raised island with 0.6-m curb offsets on each side adjacent to the through travel lanes. In restricted locations, a continuous barrier curb may be offset 0.3 m and a mountable curb offset may be 0.0 m. Under these conditions, the minimum raised median width with barrier curbs is 1.8 m and 1.2 m with mountable curbs.

6. Raised Island (Paved). For raised islands up to 5.0-m wide, the island should typically be paved to reduce the maintenance requirements of the median.

7. Raised Island (Landscaped). For raised islands greater than 5.0 m, the area between the curbs is usually backfilled and landscaped. However, where there are numerous signs, bridge piers, etc., in the island, it may be more economical to pave the raised island to eliminate excessive hand mowing.

45-2.02(03) Depressed Medians

A depressed median is typically used where practical on freeways and other divided rural arterials. Depressed medians have better drainage and snow storage characteristics and, therefore, are preferred on major highways. In addition, they provide the driver with a greater sense of comfort and freedom of operation. In the design of a depressed median, the designer should consider the following:

1. Widths. Depressed medians should be as wide as practical to allow for the addition of future travel lanes on the inside while maintaining a sufficient median width. See Chapters Fifty-three and Fifty-four.

2. Longitudinal Gradient. The recommended minimum center longitudinal gradient of a depressed median with an unpaved ditch should be 0.5% and with a paved ditch 0.3%. Under restricted conditions, absolute minimum gradients of 0.3% and 0.2%, respectively, may be used.

3. Slopes. In general, depressed medians should have slopes of 6:1.

4. Ditches. On new construction, a 1.2-m flat-bottom ditch in the center should be considered.

5. Drainage Inlets. Drainage inlets should be designed with the top of the inlet flush with the ground or with traversable safety grates on the culvert ends. See Section 49-3.0 for more information.

6. INDOT *Standard Drawings*. The INDOT *Standard Drawings* provide additional details and layout of a depressed median.

45-3.0 ROADSIDE ELEMENTS

45-3.01 Fill Slopes

Fill slopes are the slopes extending outward and downward from the edge of the shoulder to intersect the natural ground line. The slope criteria depend upon the functional classification, fill height, urban/rural location, project scope of work and the presence of curbs. In general, the Department's criteria on fill slopes for new construction is to use a 6:1 slope to the edge of the clear zone and, if the slope has not intersected the natural ground line at this point, then a 3:1 or flatter slope is used to the toe. Figure 45-3A, Typical Fill Slopes (Non-Curbed Facilities), and Figure 45-3B, Typical Fill Slopes (Curbed Facilities), present the INDOT fill slope criteria.

Although Figures 45-3A and 45-3B provide specific criteria for fill slopes, consideration must be given to right-of-way restrictions, utility considerations and roadside development in determining the appropriate fill slope for the site conditions. If practical, flatter fill slopes than indicated should be used.

** *PRACTICE POINTER* **

Grading for guardrail end treatments should not be shown on the Typical Cross Section sheet(s).

45-3.02 Cut Slopes

45-3.02(01) Typical Slope Rates

On facilities without curbs, roadside ditches are provided in cut slopes to control drainage. See Figure 45-3C, Typical Cut Slopes (Non-Curbed Facilities). As indicated in Figure 45-3C, the ditch section includes the foreslope, ditch width and backslope as appropriate for the facility type. On facilities with curbs, a shelf is provided with a backslope beyond the shelf. Where sidewalks are present or anticipated in the future, a minimum shelf width of 3.3 m should be provided. This provides a 0.3-m appurtenance strip behind the sidewalk. The minimum shelf width without a sidewalk or anticipated sidewalk may be 1.5 m. Applicable criteria are provided in Figure 45-3D, Typical Cut Slopes (Curbed Facilities). For sections with curbs, sidewalks and ditches, the designer should refer to Figure 45-3C for appropriate criteria beyond the sidewalk. The following sections provide additional information for earth and rock cuts.

45-3.02(02) Rock Cuts (Backslopes)

The backslope for most rock cuts should typically not exceed 1:6. For large rock cuts, benching of the backslope may be required. Section 18-2.08 provides the Department's design details on benching criteria in rock cuts.

45-3.02(03) Material and Soils Conditions

The designer must ensure that permanent erosion control is considered in the design of ditches in cut slopes. The Materials and Tests Division will review the existing soils conditions to determine if additional measures may be required to control erosion (e.g., additional topsoil, special plantings, paving). It will be the designer's responsibility to consider their recommendations for incorporation into the plans. As a general guide, longitudinal ditch slopes of 1% or greater will usually require sodding and slopes of 3% or greater will require a paved or riprap lining. For more information on the design of ditch linings, the designer should review Part IV and the INDOT *Standard Drawings*.

45-3.02(04) Roadside Safety

To safely accommodate a run-off-the-road vehicle, the ditch slopes should be as flat as practical. Section 49-3.02 presents specific criteria to determine desirable foreslope and backslope combinations. All hazards within the clear zone are to be removed, relocated, made breakaway or shielded. See Chapter Forty-nine.

45-3.02(05) Hydraulic Design

Part IV discusses the hydraulic design of roadside ditches. In general, the depth of the ditch should ensure that the flow line for the design discharge (e.g., Q_{10}) will be below the subgrade intercept with the fore slope. The desirable minimum longitudinal gradient for an unpaved ditch should be 0.5%. An absolute minimum longitudinal gradient of 0.3% may be used under restricted conditions.

45-3.03 Reducing the Usage of 2:1 Slopes

Slopes of 2:1 or steeper should be avoided on an INDOT project unless they are absolutely necessary. Such slopes are extremely difficult to maintain, are susceptible to erosion problems, and in some soil types have serious slope stability problems. The use of 2:1 or steeper slopes on a local public agency project will continue to be at the discretion of the local public agency.

The acceptability of using steeper than desirable sideslopes differs depending on the project design criteria as follows:

45-3.03(01) New Construction / Reconstruction Project (4R)

On a 4R project which requires additional right of way, the use of 2:1 slopes should be avoided wherever possible. In deep cuts or high fills the additional right-of-way cost to construct 3:1

slopes beyond the clear zone is generally a minor consideration. If 2:1 slopes appear to be necessary at select locations, early geotechnical investigation should be conducted to determine their suitability.

In an urban area with limited or very costly right of way, 2:1 slopes are permissible. Alternatives such as burying pipes in ditches to reduce the slopes or constructing mechanically steepened slopes should be evaluated if these practices will result in better slope stability. Another alternative is described in Section 36-6.08 which recommends the use of curbs along the shoulder under guardrail at the tops of steep slopes with high erosion potential. Details of this practice are shown in the INDOT *Standard Drawing*s.

For an Interstate 4R rehabilitation project it may not be feasible to upgrade all slopes to provide the required clear zone due to environmental constraints or right-of-way limitations. If slopes steeper than 3:1 are retained, they should be evaluated to determine if guardrail is warranted using the figures shown in Section 49-4.04. Slopes may also be evaluated using the software included in the AASHTO *Roadside Design Guide*. See Section 54-4.0.

The designer must prepare Design Exception Level Two documentation where 2:1 sideslopes are proposed on a 4R project. This should be completed at the grade review stage. The documentation must include a discussion of the economic and/or environmental reasons for needing 2:1 or steeper sideslopes.

Slopes of 3:1 instead of 2:1 should be used in rock cut areas. Most rock is sandstone or shale and will not stand vertically. Backslopes of 2:1 should be used only where good slope stability or sound rock has been verified.

45-3.03(02) 3R Project

The use of 3:1 slopes should be considered as described in Section 55-4.05(10) Item 2a. If steeper slopes are required, 2.5:1 slopes should be considered before implementing 2:1 slopes. Slopes behind guardrail at the corners of bridges should not be routinely steepened to 2:1 even though the slope may be completely protected by the guardrail.

Locations and situations that may warrant 2:1 or steeper slopes are as follows:

1. Roadway widening that encroaches into a wetlands.

2. Areas with restrictive right-of-way or very costly right-of-way.

3. Slopes at ends of large culverts, bridge spillslopes, or other locations where it is desirable to protect the slopes with riprap.

Where 2:1 slopes are specified they should be protected with erosion control blankets and capping soils suitable for growing vegetation. The designer should contact the Design Division's landscape architect concerning the possibility of capping cut and fill slopes steeper than 3:1.

45-4.0 BRIDGE AND UNDERPASS CROSS SECTIONS

The highway cross section must be carried over and under bridges, which often requires special considerations because of the confining nature of bridges and their high unit costs. The bridge or underpass section will depend upon the cross section of the approaching roadway, the highway functional classification and the project scope of work.

45-4.01 Bridges

In general, the road design criteria will determine the proper cross section width of the roadway, and the bridge design will accommodate the paved approach width across any structures within the project limits. This will provide full continuity of the roadway section for the entire project. This process will, of course, require proper communication between the road designer and bridge designer to identify and resolve any problems.

In general, the bridge cross section will be determined by the project scope of work. For new construction and bridges on 4R routes, the criteria presented in Chapter Fifty-three will determine the cross section of the bridge. For bridge projects within the limits of a 3R route, the cross section will be determined by the criteria in Chapters Fifty-four and Fifty-five. Section 40-6.0 presents project scope of work definitions and a map of the State highway system with designated 3R and 4R routes. The following will apply to the cross section of bridges:

1. Clear Roadway Width. Chapter Fifty-three presents criteria for new construction projects and bridges within the limits of a 4R route. Chapters Fifty-four and Fifty-five present criteria for bridges within the limits of a 3R route (freeway and non-freeway). For a summary of bridge width criteria, see Section 59-1.01.

2. Travelway Width Reductions. When approaching a narrow bridge, the roadway width may need to be reduced to allow the roadway to pass over the bridge. These travelway reduction transitions should be designed using the taper rates presented in Figure 45-4A, Taper Rates for Lane Reductions.

3. Auxiliary Lanes. These may be required across a structure for a variety of reasons. To determine the additional width needed for auxiliary lanes, the designer should refer to the following:

   a. Chapter Forty-eight discusses the warrants for and design of auxiliary lanes within interchanges. These may be needed across a bridge, for example, to accommodate vehicular weaving within a full cloverleaf interchange.

   b. Chapter Forty-six discusses warrants for and the design of auxiliary lanes at intersections, including two-way left-turn lanes, turning roadways and exclusive turn lanes. These may impact the design width of any structures near intersections.

   c. Section 44-2.0 discusses the warrants for and design of climbing lanes. The full width of these lanes including shoulders will be provided across any structures.

   d. Chapters Fifty-three, Fifty-four and Fifty-five provide the widths of auxiliary lanes for various project scopes of work (e.g., 3R, 4R) and facility type (e.g., arterial).

4. Cross Slopes. On tangent sections, all new and reconstructed bridges will be constructed with a typical cross slope of 2% sloping away from the crown. The 2% applies to the entire width from the crown to the face of rail or curb. The crown across the bridge will typically be in the same location as the approaching roadway crown. Note that existing bridges to remain in place may retain an existing cross slope of 1.5%.

   On superelevated roadway sections, a break may be provided between the traveled way and high-side shoulder. However, on superelevated bridges a constant slope at the superelevation rate is always provided across the entire curb-to-curb or railing-to-railing width of the bridge. This applies to both fully superelevated sections and sections within superelevated transitions.

   Note that the approach roadway will typically include a shoulder with a cross slope different from that on the bridge. For example, the typical roadway shoulder cross slope on tangent is 4%. It will be necessary to transition the roadway shoulder slope to the bridge deck slope before reaching the bridge deck. The rate of transition should be consistent with the relative longitudinal slopes used for superelevation transitions. These are presented in Section 43-3.0.

See Section 59-1.0 for cross section for bridges.

5. Medians. Section 45-2.0 discusses the design of medians. In most cases, twin parallel structures will be used to carry a median across an overpass. On long bridges and with sufficiently narrow medians, some economy in substructure costs may be realized by constructing a single structure. Depending on site conditions, a single structure may be more cost effective than twin structures where the median width is approximately 10 m or less on freeways and 6 m or less on other INDOT routes. Median width at overpasses, in general, will match the median width on the approach.

6. Sidewalks. Section 45-1.06 provides the Department's sidewalk warrants on bridges. For design details of sidewalks on bridges, see Chapter Sixty-eight.

7. Side Slopes. Section 45-3.0 presents the Department's criteria for fill and cut slopes along the roadway. If it is necessary to transition slopes, the transitions should be made such that the maximum longitudinal slope along the roadside does not exceed 20:1 at a line measured a distance of 7.5 m from the edge of traveled way.

8. Ramps. For bridges on interchange ramps, the full paved width of the ramp should be provided across the bridge. See Section 48-5.0 for criteria on ramp widths.

45-4.02 Underpasses

The cross section of an underpass has a significant impact on the size of the overpassing structure. In general, the underpass will be designed to meet the following:

1. Roadway Section. The full approach roadway section, including the median width, should be provided through the underpass section.

2. Clear Zones. Desirably, the roadside clear zone applicable to the approaching roadway section will be provided through the underpass. Section 49-2.0 presents the INDOT clear zone criteria, which are a function of design speed, traffic volumes, highway alignment and side slopes. Note that, if an auxiliary lane is provided through the underpass, this impacts the clear zone determination. Section 49-2.0 discusses specifically the measurement of clear zones where auxiliary lanes are present.

3. Travelway Width Reductions. When approaching a narrow underpass, the roadway width may need to be reduced to allow the roadway to pass under the bridge. These travelway reduction transitions should be designed using the taper rates presented in Figure 45-4A, Taper Rates for Lane Reductions.

4. Sidewalks. Section 45-1.06 provides the INDOT sidewalk warrants through underpasses.

5. Side Slopes. Section 45-4.01 discusses the rate of transition for modifying the rate of fill or cut slopes near bridges. These also apply to underpasses.

6. Future Expansion. When determining the cross section width of a highway underpass, the road designer should also consider the likelihood of future roadway widening. Widening any existing underpass in the future can be extremely expensive. Therefore, the designer should evaluate the potential for further development in the vicinity of the underpass which would significantly increase traffic volumes. If appropriate, a reasonable allowance for future widening may be made to provide sufficient lateral clearance for additional lanes.

7. Ramps. For underpasses on interchange ramps, the full paved width of the ramp including shoulders and the clear zone should be provided through the underpass. See Section 48-5.0 for criteria on ramp widths.

45-5.0 CHANGES IN ROADWAY CROSS SECTIONS

Careful consideration must be given to the design of transitions from multi-lane facilities to 2-lane facilities. These are complex decision-making areas for a driver, who may not be expecting the lane reduction. Therefore, the designer should use the safest criteria practical, whether these connections are permanent or temporary.

The horizontal alignment for permanent and temporary transitions should follow the criteria presented in Chapter Forty-three. All temporary connections should be designed as new facilities. This includes, but is not limited to, superelevation, transition lengths, reverse curves and the tangent length between curves.

Decision sight distance should be provided to and throughout the transition area. To achieve this objective, the project termini may need to be adjusted.

The following figures illustrate typical INDOT designs for various transitions:

1. Figure 45-5A, Example of a Curved Alignment Transition (2-Lane Undivided to a 4-Lane Divided), provides the details for a transition from a 2-lane to a 4-lane facility on a curve. The transition may also be designed on a tangent. The designer must consider the design of the horizontal alignment features. See Chapter Forty-three.

2. Figure 45-5B, Split Transition (2-Lane Undivided to a 4-Lane Divided), provides the details for a tangent section.

3. Figure 45-5C, Split Transition (4-Lane Undivided to a 4-Lane Divided), provides the details for a tangent section.

4. Figure 45-5D, Two-Way Left-Turn Lane Transition, provides the details for a split transition from a 4-lane undivided to a 5-lane TWLTL section on a tangent.

45-6.0 RIGHT-OF-WAY

45-6.01 Definitions

The following right-of-way (R/W) definitions will apply:

1. Permanent R/W. R/W acquired for permanent ownership by the State for activities which are the responsibility of the State for an indefinite period of time. The State obtains the title to the property. Permanent R/W is typically acquired for roadway, utility accommodation, fill and cut slopes, etc.

2. Temporary R/W. R/W required for the legal right of usage by the State to serve a specific purpose for a limited period of time, typically until the project is completed or for building removal until the building is removed, or for condemnation cases until three years beyond December of the anticipated letting year at the time of condemnation. Once the activity is completed, the State yields its legal right of usage and returns the land to its original condition as close as practical.

3. R/W Easements. R/W required with the perpetual right to construct and maintain a public highway and incidental facilities over and across the surface of lands. Types of R/W easements include:

    a. highway easements (e.g., relocating, cleaning and repairing of a legal ditch);

b. utility easements for private facilities (e.g., pipelines, private access roads); and
c. storm sewer easements.

4. Perpetual Easements. R/W acquired with the perpetual or permanent right to construct and maintain an off-road facility such as sewer lines, drainage ditch or any other items (except items under the jurisdiction and control of a county drainage board) outside of the highway or service area R/W.

46-6.02 Widths

The minimum right-of-way (R/W) width for all functional classifications will be the sum of the travel lanes, shoulders, median width (if applicable), ditches, plus the necessary width for fill and cut slopes or for roadside clear zones, whichever is greater. Desirably, the overall R/W width should be increased to provide additional width for:

1. Maintenance. A 2-m to 5-m maintenance area should be provided along each side of the roadway to accommodate maintenance equipment at the top or bottom of cut and fill slopes.

2. Utility Corridor. A utility corridor, for underground and overhead utilities, should be provided beyond the roadside clear zone. Chapter Ten provides additional information on the placement of utilities within the highway R/W.

3. Future Expansion. The designer should consider obtaining sufficient R/W initially to meet the anticipated long-term corridor growth. This may include obtaining additional R/W for:

   a. a wider median to allow for the addition of future through travel lanes,
   b. expansion of an existing interchange,
   c. a future interchange, or
   d. expanding an existing 2-lane facility to a 4-lane divided highway.

The R/W width should be uniform, but this is not a necessity. In urban areas, variable widths may be necessary due to existing development; varying side slopes and embankment heights may make it desirable to vary the R/W width; and R/W limits will likely have to be adjusted at intersections and freeway interchanges. Other special R/W controls should also be considered:

1. At horizontal curves and intersections, additional R/W may be warranted to ensure that the necessary sight distances are always available in the future.

2. In areas where the necessary R/W widths cannot be reasonably obtained, the designer will have to consider the advisability of using steeper slopes, revising grades, or using retaining structures.

3. Special R/W considerations at interchanges are discussed in Chapter Forty-eight.

Chapter Eighty-five provides additional criteria for establishing the R/W limits. The designer will coordinate with the Land Acquisition Division on the purchase of R/W for highway projects.

45-7.0 FRONTAGE ROADS

45-7.01 General

Frontage roads serve numerous functions, depending on the type of facility served and the character of the surrounding area. They may be used to control access to the facility, to function as a street serving adjoining property, and to maintain circulation of traffic on each side of the main highway. Frontage roads segregate local traffic from the higher-speed through traffic and serve driveways of residences and commercial establishments along the highway. Connections between the main highway and frontage roads, usually provided at crossroads, furnish access between through roads and adjacent property. Thus, the through character of the highway is preserved and is unaffected by subsequent development along the roadsides.

Frontage roads may be used on all types of highways. Their greatest use is adjacent to freeways where their primary function is to distribute and collect traffic between local streets and the freeway interchanges. In some circumstances, frontage roads are also desirable on arterial streets both in urban and suburban areas.

Despite their advantages, the use of continuous frontage roads on relatively high-speed arterial streets with intersections at grade may be undesirable. At the cross streets, the various through and turning movements at several closely spaced intersections greatly increase the accident potential. The multiple intersections are also vulnerable to wrong-way entrances. Traffic operations are improved if the frontage roads are located a considerable distance from the main highway at the intersecting crossroads in order to lengthen the spacing between successive intersections along the crossroads. See Section 45-7.03.

Frontage roads generally are parallel to the roadway for through traffic. They may or may not be continuous, and they may be provided on one or both sides of the arterial.

For private frontage or access roads, an economic analysis needs to be completed to ensure that construction of the frontage road will be cost effective versus purchasing the property.

45-7.02 Functional Classification

The normal design elements of pavement width, cross slope, horizontal and vertical alignment, etc., should be provided consistent with the functional operation of the frontage road. That is, the same considerations relative to functional classification, design speed, traffic volumes, etc., apply to frontage roads as they would to any other highway.

For high-volume, continuous frontage roads, the desirable functional classification will be one level below that of the main highway classification.

For low-volume, non-continuous frontage roads, the design functional classification should be a local road or street.

45-7.03 Design

45-7.03(01) Design Elements

The selection of the appropriate design criteria is based on the functional classification of the frontage road. Once the functional classification has been determined, the appropriate design speed, lane and shoulder widths, etc., from the tables in Chapters Fifty-three through Fifty-five can be selected.

45-7.03(02) One-Way/Two-Way

From an operational and safety perspective, one-way frontage roads are much preferred to two-way. One-way operations may inconvenience local traffic to some extent, but the advantages in reducing vehicular and pedestrian conflicts at intersecting streets often fully compensate for this inconvenience. In addition, there is some savings in pavement and right-of-way width. Two-way frontage roads at high-volume, at-grade intersections complicate crossing and turning movements. Off ramps (e.g., slip ramps) joining two-way frontage roads are not used because of the potential for wrong-way entry is increased.

Two-way frontage roads may be considered for partially developed urban areas where the adjoining street system is so irregular or so disconnected that one-way operation would introduce considerable added travel distance and cause undue inconvenience. Two-way frontage roads may also be appropriate for suburban or rural areas where points of access to the through facility from the frontage road are widely spaced.

45-7.03(03) Outer Separation

The area between the main highway and a frontage road or street is the outer separation. The separation functions as a buffer between the through traffic on the main highway and the local traffic on the frontage road. This separation also provides space for shoulders and ramp connections to or from the through facility.

The wider the outer separation, the less influence local traffic will have on through traffic. Wider separations lend themselves to landscape treatments and enhance the appearance of both the highway and the adjoining property. Desirably, the outer separation between the through arterial and the frontage road will be 30 m in rural areas and 20 m in urban areas. These distances are measured between the edges of the through lanes for the main highway and frontage road. Desirably, the intersection of the frontage road and crossroad should be 50 m or more from the intersection of the arterial and crossroad. This lengthens the spacing between successive intersections along the crossroad. The minimum width of outer separation will be that required for the shoulder adjacent to the main highway, frontage road shoulder or shoulder offsets and for a median type barrier.

A substantial width is particularly advantageous at intersections with cross streets. A wide outer separation minimizes vehicular and pedestrian conflicts. At intersections, the outer separation should be based on future traffic considerations.

45-7.03(04) Access

Connections between the main highway and the frontage road are an important design element. On arterials with slow-moving traffic and one-way frontage roads, slip ramps or simple openings in a narrow outer separation may work reasonably well. Slip ramps from one-way frontage roads and freeways are acceptable. However, slip ramps from a freeway to two-way frontage roads are undesirable because they tend to induce wrong-way entry onto the freeway and may cause crashes at the intersection of the ramp and frontage road. Therefore, on freeways and other arterials with high operating speeds and two-way frontage roads, the access to the freeway should be provided at interchanges. Details for the ramp/frontage road design are provided in Section 48-6.04.

45-7.04 Design Considerations (Frontage-Road and Local-Road Intersections)

Section 40-8.0 discusses INDOT criteria procedures for approving exceptions to INDOT design criteria. In general, these apply to the design of frontage roads. However, frontage-road intersections with higher volume highways merits a special discussion.

Existing, reconstructed or proposed intersections between frontage roads and other facilities may need to include a relatively restricted horizontal or vertical alignment on the frontage road as it approaches the intersection. It may be prudent to use reduced alignment features near intersections assuming that a prudent driver will reduce speed as the vehicle approaches the intersection with the higher volume facility. Therefore, reduced alignment features for that portion of the frontage road near the intersection may be incorporated if most of the following conditions are met.

1. The frontage road is in a rural area.
2. The road has the appearance of a frontage road.
3. The frontage road does not have a long length (over 800 m) of open-highway conditions that could lead a motorist to conclude he is on a through road.
4. The design speed of the frontage road is 80 km/h or less.
5. There is a sufficient tangent (150 m to 200 m) to allow for advance curve warning and intersection signs.
6. The projected AADT on the frontage road must be 750 vpd or less.
7. The intersection approach should be controlled by a stop sign for the foreseeable future.
8. Stopping sight distance for the design speed on the frontage road or the local road is available at the approach.

Failure to meet any one of these criteria should not preclude submitting a design exception request for reduced alignment features if valid justification can be presented. Such factors as heavy development along the road; a posted speed limit less than the design speed; adverse impacts to property owners and the environment; stable, but higher than recommended, AADTs; construction costs; adequate advance signing; and predicted driver reaction to the highway alignment should be considered.